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RESPONSE OF LATE WHITE CABBAGE TO FERTIGATION AND BROADCAST NITROGEN APPLICATION

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Summary

Research was conducted in 1997-1998 on response of late white cabbage on drip irrigation and traditional broadcast fertilization as compared to liquid fertilization. Use of fertigation with nitrogen or multiple fertilizer "Polyfeed" has caused a significant rise in the yield of late white cabbage considering the traditional, broadcasted use of nitrogen. Liquid-applied fertilizers were utilized more effectively as compared to broadcast-applied nitrogen. Lowering the dose of nitrogen in fertigation from 200 to 125 kg/ha has not decreased the yield significantly. Due to fertigation of nitrogen or multiple fertilizer, the nitrogen status of plants was uniform within the whole growth period and markedly better than that obtained by dredge-applied nitrogen fertilizing. No differences in yield, dry matter production and contents of nitrate and total nitrogen have been stated between surface and subsurface fertigation.

key words: cabbage, fertilizing, nitrogen, irrigation, fertigation

INTRODUCTION

The yield of late white cabbage is influenced in great measure by irrigation and fertilizing. Nitrogen is the nutritive component most crucial for yielding. Its recommended doses range from 150 to 250 kg/ha. Most frequently 1/3 of the dose is broadcasted before the vegetation, together with the P-K fertilization, and the remaining part – by top-dressing, usually in two doses. The utilization of nitrogen depends on moisture of the soil. As well excess as deficiency of water in the soil cause that the response of plants to nitrogen fertilizer remains limited, decreasing the yield. In the case of overabundant precipitation and too high irrigation doses, a part of nitrogen can be leached out of the reach of the root system. After Sanchez et al. (1994) losses of nitrogen were limited when irrigation doses have corresponded with the volume of water volatilized in the process of evapotranspiration (ET). However, water doses applied even in that manner did not prevent nitrogen losses due to precipitation, especially by higher level of nitrogen fertilization.

Administering liquid fertilizers by means of a system of drip irrigation (fertigation) allows precisely to match the time of fertilizing with requirements of the plant as well as uniformly to distribute the nutritive components in the soil (Hartz & Hochmuth 1996). According to McPharlin et al. (1995), fertigation has rised the efficacy of utilizing nitrogen due to maintaining its concentration in the soil at uniform and stable level and limiting its losses due to leaching. Drip irrigation and weekly fertigation caused an increase of the yield as compared to preplant fertigation and sprinkled irrigation (Clough et al. 1990). After Swiader et al.(1994), N - K fertigation enabled to limit the fertilizer doses as compared to broadcast application of solid fertilizers. Properly conducted fertigation decreased also contaminating ground-water with nitrates.

Due to natural abundance of the soil in nutritive components, fertigation with nutrients containing all components is not applied in field growing of vegetables. Most frequently liquid fertilization with nitrogen and sometimes with potassium is practised. A part of the nitrigen dose (20-30%) is broadcasted preplant, especially on soils not very abundant as well as in situations not needing irrigation in the first period of plant growth (Locascio et al. 1985). The frequency of fertigation is not as important as applying proper nutrient dose at the time of highest requirements of the plants (Cook & Sanders 1991, Storile et al. 1995). Considering, however, the possibility of losses due to leaching, small and frequent doses of water with nutrients are usually applied.

In the experiments conducted, liquid fertilizing with nitrogen and complex fertilizer was compared to traditional braodcast fertilizing, both in conditions of trickle irrigation and without it.

MATERIAL AND METHODS

Research on response of drip-irrigated and traditionally broadcast-fertilized cabbage as compared to liquid fertilization of this vegetable was conducted in 1997 and 1998. The experiment (single factor, four replications) was carried out on sandy loam soil with 1% content of organic matter and pH equal to 6.5. Considering high contents of phosphorus in the soil, fertilizing with this nutrient was not applied. Potassium at the dose of 200 kg K_2O/ha and a part of nitrogen at an amount of 75 kg/ha were applied preplant whereas the remaining part of nitrogen – sidedress. Experimental objects and fertilizer doses applied are presented in the Table 1.

In the first research year objects without irrigation, irrigated, and fertigated with nitrogen were compared. Irrigating pipes T-tape TSX 508-20-500 were applied for trickle irrigation and fertigation. In objects with irrigation and fertigation the pipes were placed at the soil surface (surface irrigation and fertigation) or at the depth of 15 cm (subsurface irrigation and fertigation) at a distance of 45 cm from each other. The total dose of nitrogen in objects either without irrigation or with trickle irrigation was 200 kg/ha.

Table 1. Treatments and total nitrogen doses in 1997 and 1998.

Treatment	Amount of nitrogen applied kg/ha			
	Preplant	Sidedress		Total
		Broadcast	Fertigation	
1997				
1. Broadcast N application (BN)	75	75+50(125)	-	200
2. BN + Surface Trickle Irrigation (STI)	75	75+50(125)	-	200
3. BN + Subsurface Trickle Irrigation (SSTI)	75	125(75+50)	-	200
4. Surface Fertigation of N(SF-N)	75	-	125	200
5. Subsurface Fertigation of N(SSF-N)	75	-	125	200
6. SF of reduced N dose (SF-N125)	0	-	125	125
1998				
1. BN	75	75+50(125)	-	200
2. BN+STI	75	75+50(125)	-	200
3. SF-N	75	-	125	200
4. SSF-N	75	-	125	200
5. SF of complex fertilizer (SF-CF)	75	-	125	200
6. SSF of complex fertilizer (SSF-CF)	75	-	125	200

In objects with fertigation, this dose, whose part (75 kg/ha) was applied preplant and the remnant sidedress as liquid fertilizing, was compared to the dose of nitrogen decreased to 125 kg/ha and applied exclusively sidedress, as liquid fertilizing.

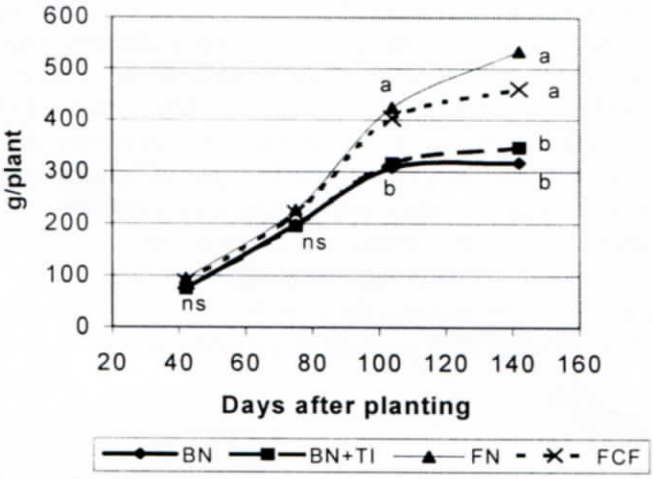
In the second research year instead, objects without irrigation were compared to objects with surface trickle irrigation and to other objects, either with fertigation of nitrogen or multiple fertilizer "Polyfeed" executed in a surface or subsurface manner. The total nitrogen dose was in this year 200 kg/ha in all objects. For nitrogen fertigation a solution of ammonium nitrate was used. In objects with "Polyfeed" fertigation, preplant fertilizing with potassium was not applied. As far as nitrogen is concerned, its concentration in the multiple fertilizer "Polyfeed" was 200 mg of N/l. The frequency of trickle irrigation and fertigation depended on moisture of the soil, and their application was based on measures of the water potential of the soil by means of a Watermark Soil Moisture Meter. Irrigation and fertigation were initiated when the measurements reached —40 kPa. Single water and nutrient dose amounted 10 l/running m/h. Liquid fertilizing proceeded until the intended nitrogen dose has been

applied.

White cabbage of Delus F_1 cultivar was planted on May, 26 and 21, whereas harvesting took place on October, 3 and 10 in subsequent research years, respectively. The plot area amounted 8.1 m^2 and the spacing of plants was 45 x 45 cm. Sampling of whole plants and young, full grown leaves for assaying nitrogen contents in total and nitrate forms, respectively, was continued from all objects and replications during the growth season After weighing fresh mass of the plants, the samples were dried in a temperature of 65°C and grinded. Total nitrogen was assayed by means of the micro-Kjeldhal method, whereas the nitrate one – with the modified method of Spurway. The results (marketable yield of cabbage, total and nitrate contents of nitrogen) were elaborated statistically by means of the Student's t-test.

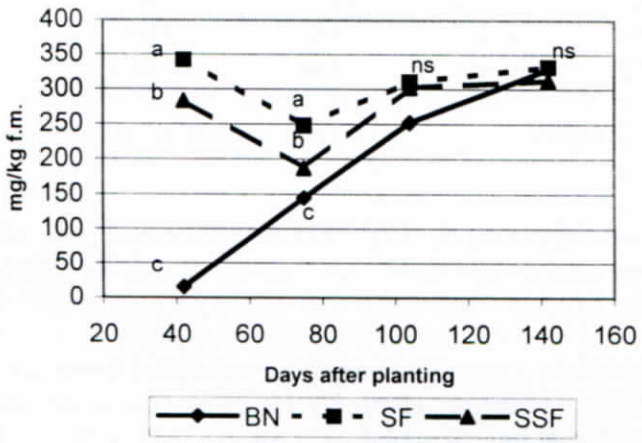
RESULTS AND DISCUSSION

Growth response and tissue N concentration. In objects compared, dry matter production in cabbage did not differ remarkably during the first half of the growth season, until 75 days have gone by from transplanting it into the field (Fig. 1). Significant differences were stated after 104 and 142 days.The dry matter production in broadcast fertilized cabbage was significantly lower than that of plants fertilized with liquid nitrogen or multiple fertilizer "Polyfeed". Trickle irrigation did not influence significantly the production of dry matter as compared to plants fertilized with identical nitrogen dose without irrigation. No significant differences in dry matter production have been stated as well between plants fertigated with nitrogen and with the complex fertilizer as between plants subjected to surface and subsurface fertigation. The contents of nitrate nitrogen in leaves of cabbage depended on growth stage and manner of nitrogen application; its lowest contents was stated by broadcasting the fertilizer, 42 days after transplanting cabbage, the highest instead – by surface fertigation (Fig. 2). Similar dependences were stated 75 days after transplanting cabbage, but 104 and 142 days after transplanting, the contents of the nitrate form of N were approximated for the investigated nitrogen application manners and did not differ significantly. As results from Fig.2, the state of feeding plants with nitrogen was best and at approximated level through whole growth season, when surface fertigation was applied. The cause of a significantly lower contents of nitrate nitrogen in leaves of cabbage during the first half of the growth season by subsurface fertigation or broadcast N application, could be the impeded utilization of nitrogen by the root system, taking up a limited volume of the soil at this growth stage.



TI - trickle irrigation FN - nitrogen fertigation
FCF - complex fertilizer fertigation

Fig.1. Effect of fertigation and broadcast N application on dry matter production (1998)



SF - surface fertigation SSF - subsurface fertigation

Fig. 2. Effect of fertilizing manner on contents of nitrate nitrogen in leaves of cabbage (1998)

The contents of total nitrogen depended on growth stage of the plants and on fertilization manner (Table 2). In general, the contents of total nitrogen in cabbage plants diminished in the course of the growth period. After 42 days from transplanting, no significant differences in contents of total nitrogen were stated in plants coming from combinations under comparison. In the later growth period, i.e. 75 and 104 days after transplanting, a significantly higher contents of total nitrogen was ascertained in plants subjected to fertigation than nourished by broadcasting nitrogen. During the harvest, executed 142 days after transplanting, the highest contents of total nitrogen was stated in plants fertilized with the liquid mixture of "Polyfeed", whereas the lowest one – by broadcast N application and trickle irrigation. Despite applying the same nitrogen dose, a higher contents of total nitrogen was ascertained by fertigation with the complex fertilizer "Polyfeed" than by fertigation with nitrogen in the form of ammonium nitrate.

Table 2. Effect of fertilizing manner on contents of total nitrogen (% dry wt.) in cabbage plants in the course of the growth season 1998.

Treatment	Days from transplanting			
	42	75	104	142
1. BN	2.47 a	1.96 b	1.71 c	1.85 bc
2. BN+STI	2.47 a	1.55 c	1.79 bc	1.75 c
3. SF-N	2.77 a	2.09 ab	1.93 abc	1.87 bc
4. SSF-N	2.70 a	2.18 ab	2.11 a	1.80 bc
5. SF-CF	3.00 a	2.36 a	2.20 a	1.99 ab
6. SSF-CF	2.48 a	1.98 b	2.10 ab	2.15 a

Means within a column followed by the same letter are not significantly different at the 5% level

Yield response. The lowest cabbage yield in 1997 was obtained with broadcast N fertilizing without trickle irrigation (Fig. 3). As well trickle irrigation as fertigation of nitrogen have significantly increased the yield of cabbage. No significant differences instead, have been ascertained between both surface and subsurface irrigation and fertigation. Lowering the liquid applied nitrogen dose to 125 kg/ha has allowed to reach a yield similar to that obtained either by fertigation with a dose of 200 kg N/ha or by trickle irrigation and broadcasted nitrogen dose of 200 kg/ha.

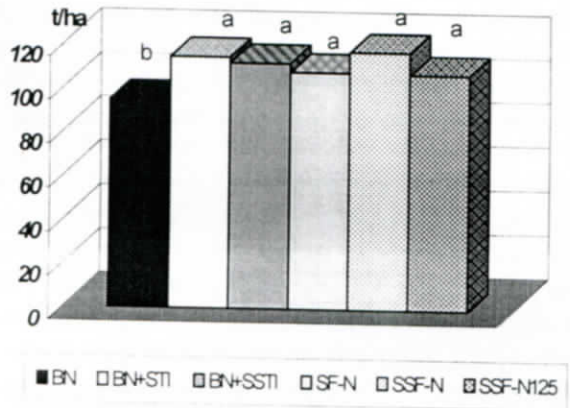


Fig. 3. Effect of fertilizing manner on yield of late cabbage (1997)

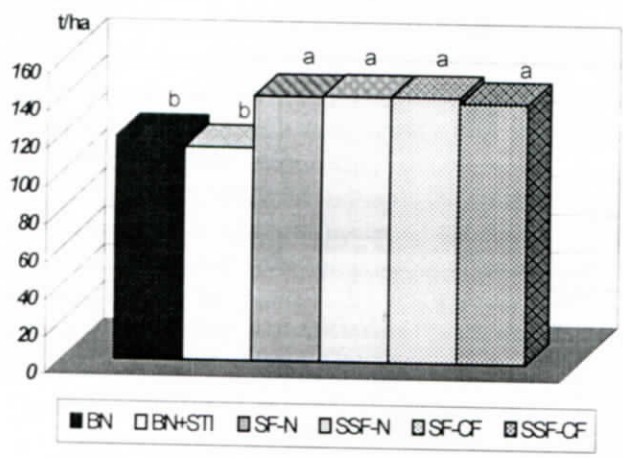


Fig.4. Effect of fertilizing manner on yield of late cabbage (1998)

In 1998 the lowest yield of late cabbage was obtained by broadcast N application, as well without trickle irrigation as with it (Fig.4). As compared to broadcast N application, a significantly higher yield of cabbage was obtained by liquid N fertilizing as well as by fertigation of complex fertlizer "Polyfeed". This yield was about 20% higher by fertigation than by broadcast fertilizing. No significant differences have been stated between surface and subsurface fertigation, as well as between fertigation of nitrogen and that of the complex fertilizer.

The research conducted has shown that fertilizers administered in liquid form were more effectively utilized as compared to those applied by broadcasting, what is conformable to the results of McPharlin et al. (1995). The yield of cabbage obtained due to fertigation was in both research years higher than that from plots with broadcast fertilizing, and lowering nitrogen dose from 200 to 125 kg/ha has not significantly decreased the yield. This is a confirmation of the results obtained by Swiader et al. (1994), according to which fertigation enables reducing fertilizer doses as compared to broadcast fertilizing. In the first research year also trickle irrigation has rised the efficacy of utilizing nitrogen and increased the yield of cabbage. After Clough et al. (1990) not only fertigation but also trickle irrigation have caused an increase of the yield as compared to preplant fertilizing and sprinkler irrigation. In the second research year with abundant and uniformly distributed precipitations, trickle irrigation did not much influence the yield, and if, then causing its slight decrease. It might have been generated by leaching nitrogen beyond the reach of the root system (Sanchez et al. 1994). The state of nourishment of the plants with nitrogen was by fertigation uniform during the whole growth season and through 2/3 of this period significantly better than by broadcast N application. This has favourably influenced the rise of dry matter, being in the second half of the vegetation period significantly greater in plants under fertigation than under broadcast fertilizing. The higher contents of total nitrogen speaks also well for better utilizing this component in plants under fertigation.

No difference between the yield of plants fertigated in surface and subsurface manner was stated; this is a confirmation of the results of other investigations, according to which applying appropriate dose of feeding components at the time of highest demands of the plant is by fertigation more important than the frequency or manner of their administering (Cook and Sanders 1991, Swiader et al. 1994, Storlie et al. 1995, Hartz and Hochmuth 1996).

CONCLUSIONS

1. The yield of late white cabbage was significantly higher by fertigation than by broadcast fertilization. Lowering the dose of liquid-applied nitrogen to 125 kg/ha has afforded a yield similar to that obtained by fertigation with 200 kg/ha or by drip irrigation and broadcasted nitrogen dose of 200 kg/ha.
2. Due to fertigation with nitrogen and a multiple fertilizer, the nitrogen status of plants was uniform within the whole growth period and markedly better

than that obtained by trickle-applied nitrogen fertilizing.

3. No differences in yield, dry matter production and nitrogen contents, as well in nitrate as in general form have been stated between surface and subsurface fertigation.

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REAKCJA KAPUSTY BIAŁEJ PÓŹNEJ NA FERTYGACJĘ I POSYPOWE NAWOŻENIE AZOTEM

Streszczenie

W latach 1997-1998 przeprowadzono badania nad reakcją kapusty białej późnej na nawadnianie kroplowe i tradycyjne posypowe nawożenie w porównaniu do nawożenia płynnego. Stosowanie płynnego nawożenia azotem i pożywką wieloskładnikową „Polyfeed", spowodowało istotny wzrost plonu kapusty białej późnej w stosunku do tradycyjnego, posypowego stosowania azotu. Nawozy podawane w formie płynnej były efektywniej wykorzystywane w porównaniu do azotu stosowanego posypowo. Obniżenie dawki azotu stosowanej w postaci płynnej (fertygacja) z 200 do 125 kg/ha nie spowodowało istotnego obniżenia plonu. Przy stosowaniu fertygacji azotem i pożywką wieloskładnikową stan odżywienia roślin azotem był równomierny przez cały okres wegetacji i znacznie lepszy niż przy stosowaniu posypowego nawożenia azotem. Nie stwierdzono różnic w plonie, produkcji suchej masy oraz zawartości azotu azotanowego i ogólnego pomiędzy fertygacją powierzchniową i wgłębną.